



Distributed Air-Ground Traffic Management Research

**Human Factors and Operations
Project
NASA Ames Research Center**

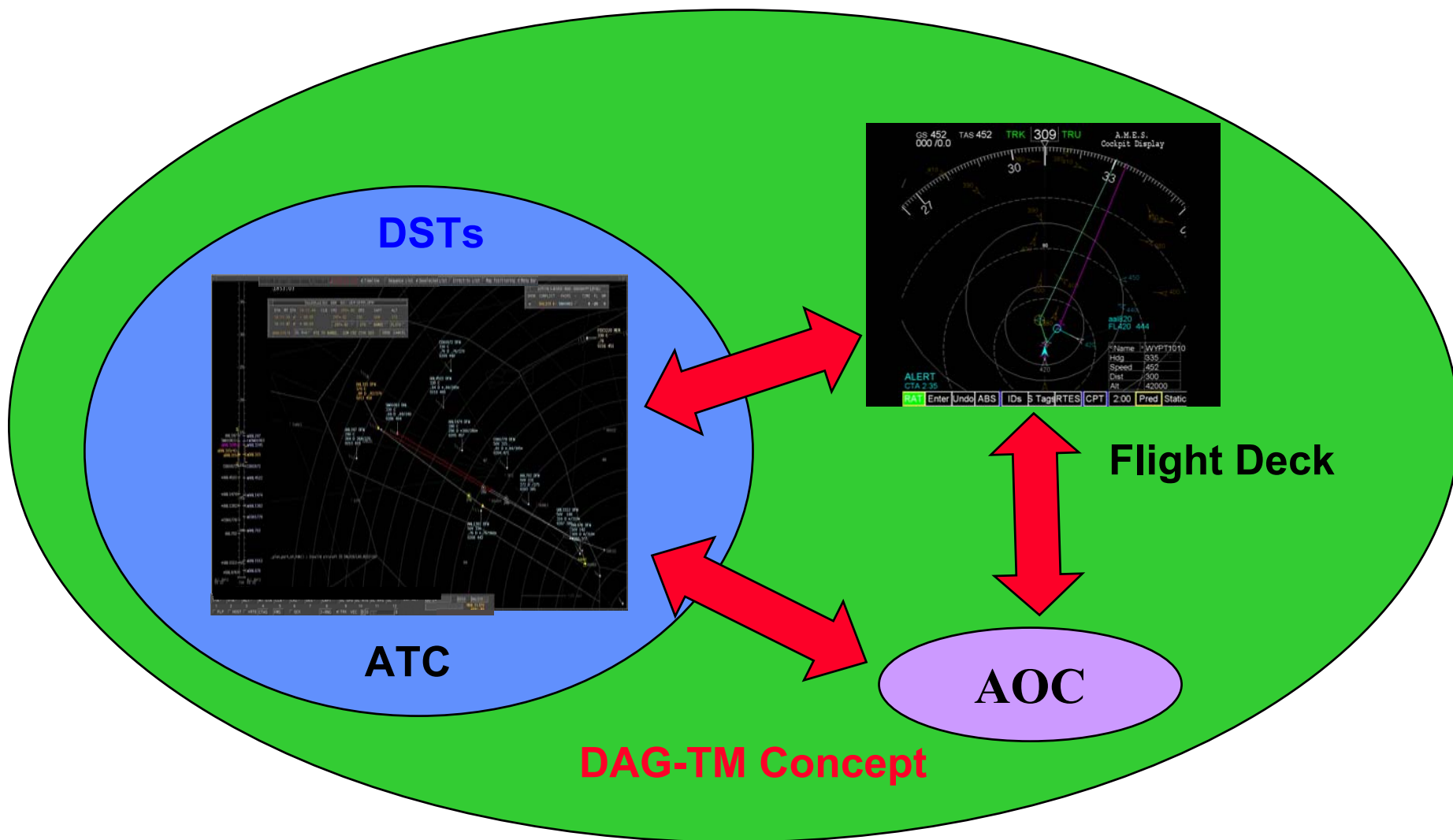
Advanced Air Transportation Technologies Project

- **Goal**
 - In alliance with the FAA, enable the next generation of increases in efficiency, flexibility, capacity, and safety of aircraft operations within the US and global airspace system.
- **Focus**
 - Develop human-centered automation to assist air traffic management in short and intermediate term decision making between pilots, controllers, and dispatchers.

Focus Areas

- **Develop en route and terminal decision support tools for FAA Free Flight Phases 1 and 2**
 - Enhance capabilities of present air traffic system
 - Deliver CTAS decision support tools to the FAA
- **Distributed Air-Ground Traffic Management (DAG-TM) Research**
 - Free Flight concept exploration
 - Evaluate feasibility of making major changes to current system and procedures
 - Deliver tested concepts to the FAA

Automation Tools and DAG-TM



DAG-TM Concept Elements

- **Four concept elements (CEs) are being pursued:**
 - **CE-5: Free Maneuvering for User-preferred Separation Assurance and Local traffic flow management (TFM) Conformance**
 - **CE-6: Trajectory Negotiation for User-preferred Separation Assurance and Local TFM Conformance**
 - **CE-7: Collaboration for Mitigating Local TFM Constraints due to Weather, Special Use Airspace, and Complexity**
 - **CE-11: Self-spacing for Merging and In-trail Separation**

CE-5:**Free Maneuvering for User-preferred Separation Assurance
and Local TFM Conformance**

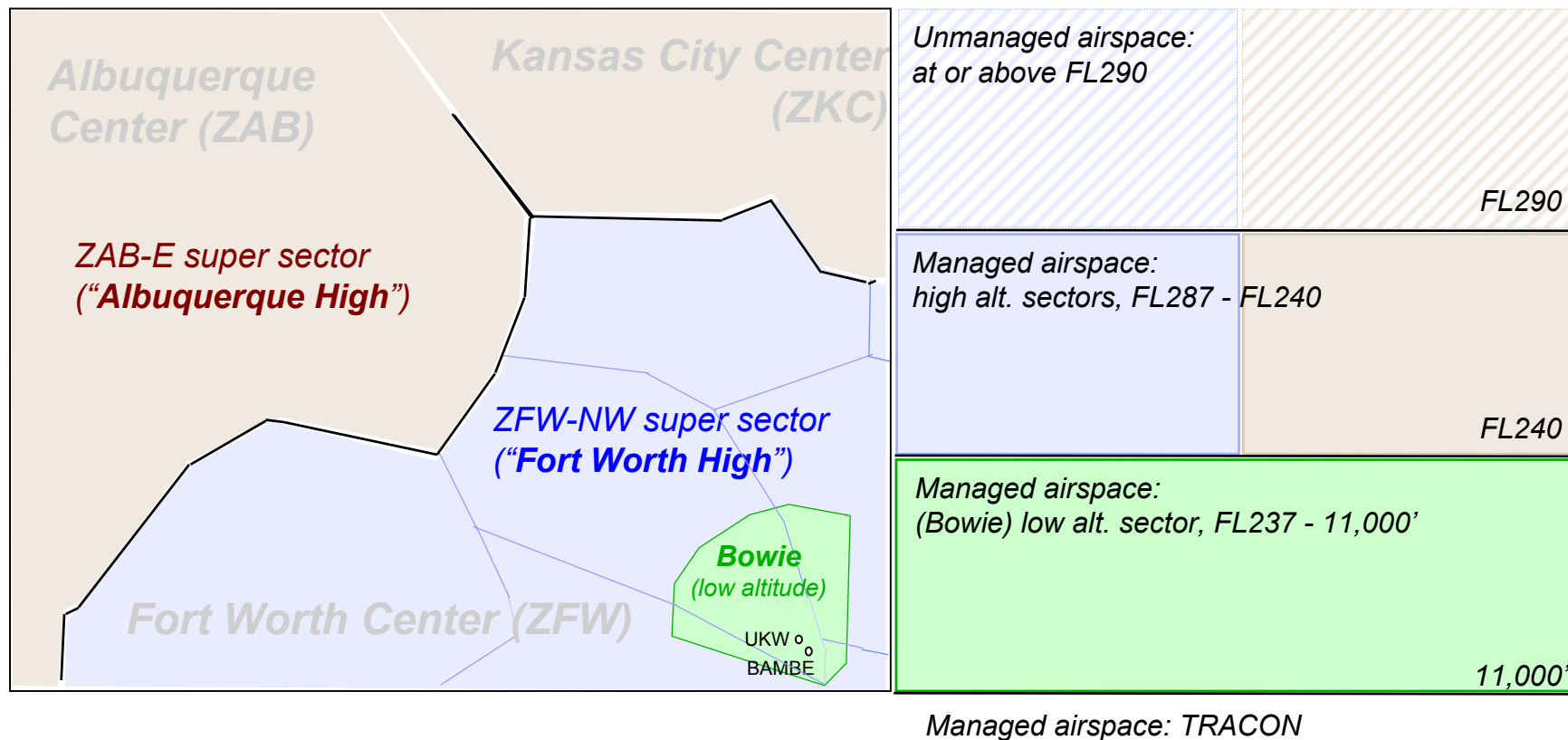
- **Problem:**
 - **Potential traffic separation conflicts may cause controller-issued deviations that are conservative or not preferred by users**
 - **Users may not always be able to fly preferred trajectories**
- **Solution:**
 - **Air: Cockpit Display of Traffic Information (CDTI)-equipped aircraft maneuver freely for separation assurance**
 - **Ground: Controller monitors separation (with complementary ground-based tools) and provides separation assurance for non-equipped aircraft**

CE 6:**Trajectory Negotiation for User-preferred Separation Assurance and Local TFM Conformance**

- **Problem:**
 - **Potential traffic separation conflicts may cause controller-issued deviations that are conservative or not preferred by users**
 - **Users may not always be able to fly preferred trajectories**
- **Solution:**
 - **User and controller negotiate for efficient resolution of conflicts**
 - **User-controller data exchange (intent, winds) for improved trajectory prediction**
 - **Controller uses enhanced DSTs with conflict detection & resolution capabilities**
 - **ATC moves to a “trajectory-based” orientation**

Assumptions for DAG, January 2002

- All aircraft are FMS, data link, and CDTI equipped.
- Aircraft are not RTA equipped at this point in development. However...
- ➔ *During the January 2002 simulation, meter fix RTA advisories will be uplinked to arriving aircraft, along with cruise speed advisories to assist them in meeting the recommended RTA.*
- All aircraft at or above FL290 are in Free Flight, all aircraft at or below FL280 are ATC-controlled.
- Aircraft must be cleared to enter Free Flight airspace (FL290 and above).
- Aircraft must be cleared to descend into controlled airspace (below FL290), and will be transitioned to positive control by ATC at that time.
- ATC may cancel Free Flight at any time.
- All arriving aircraft are flying the Bowie F2 Arrival or Gregs F1 Arrival.



Pilots use CDTI trajectory tools to resolve traffic conflicts and plan RTA compliant descent into controlled airspace. All changes are broadcast.

High altitude controllers use CTAS tools (TMA, conflict probe) to monitor en route and arrival aircraft.

Controller reviews downlinked flight plan after flight crew requests clearance to enter controlled airspace. If acceptable, aircraft is cleared to enter on FMS arrival.

Controllers use CTAS tools to monitor and fine tune the arrival plan. They may issue cruise and descent speeds and route changes by voice or datalink to controlled arrival aircraft.

Automatic Information Exchange:

- Downlink aircraft ADS state.
- Uplink descent winds to synchronize trajectory computations.
- Uplink TMA meter fix times (RTAs) and cruise speed advisories.
- Downlink FMS trajectory whenever it changes.

Free Flight to Controlled Flight Transition

Pilots request clearance to enter controlled airspace (below FL290). Aircraft begins descent in Free Flight with automatic transition to positive control after descending below FL290.

Pilots use FMS to fly precise VNAV descents from TOD to the TRACON boundary.

Center

TRACON

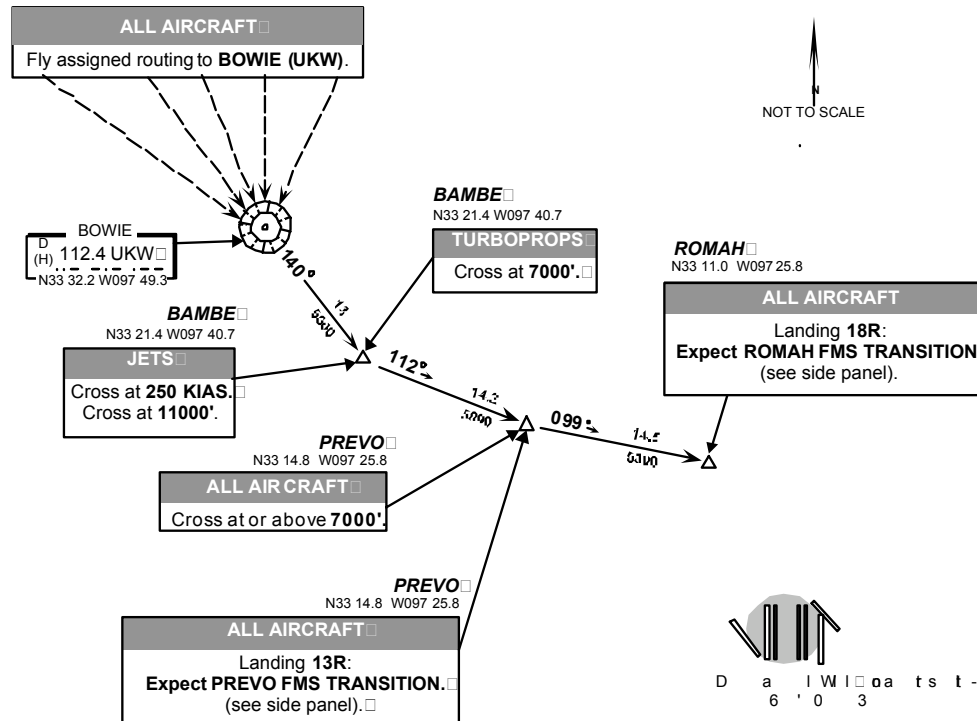
Pilots use CDTI & guidance to self-space behind a designated aircraft.

TRACON controllers can clear pilots to self-space behind a designated aircraft.

BOWIE F2 ARRIVAL (UKWF2) ROMAH (ROMAH) AND PREVO (PREVO) FMS TRANSITIONS TO ILS13R AND 1LS18R

DALLAS-FORT WORTH, TEXAS
DALLAS-FORT WORTH INTL

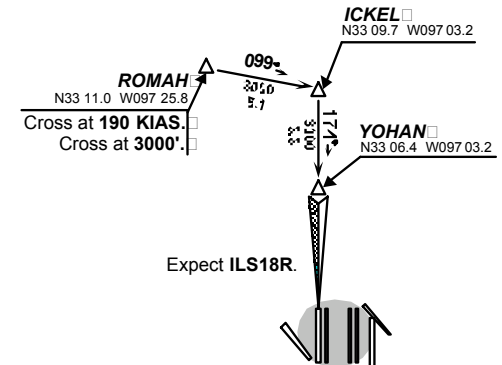
ATIS **123.77**
REGIONAL Approach **118.1 133.62**



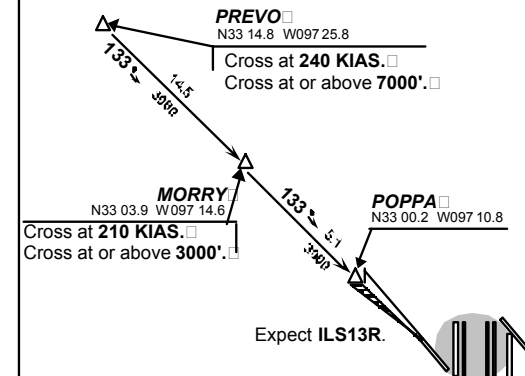
BOWIE F2 ARRIVAL NOTES:

- "Cleared to DFW via the BOWIE F2 Arrival."
- The BOWIE F2 Arrival includes the aircraft's assigned lateral route to **BOWIE**.
- This is a clearance for the lateral routing only of the BOWIE F2 Arrival to **ROMAH**.
- "Descend via the BOWIE F2 Arrival, (descend at XXX IAS)."
- This is a clearance to descend at the VNAV Top-of-Descent to the published **BAMBE** altitude or other cleared altitude.
- Vertical navigation is not at pilot's discretion.
- Maintain current altitude until the VNAV Top-of-Descent.
- Maintain cruise Mach in descent until reaching the cleared descent speed.
- Report leaving altitude.
- Comply with assigned speeds.
- Advise Regional Approach on initial contact that you are on the BOWIE F2 Arrival.

ROMAH (ROMAH) FMS TRANSITION



PREVO (PREVO) FMS TRANSITION



Notes:

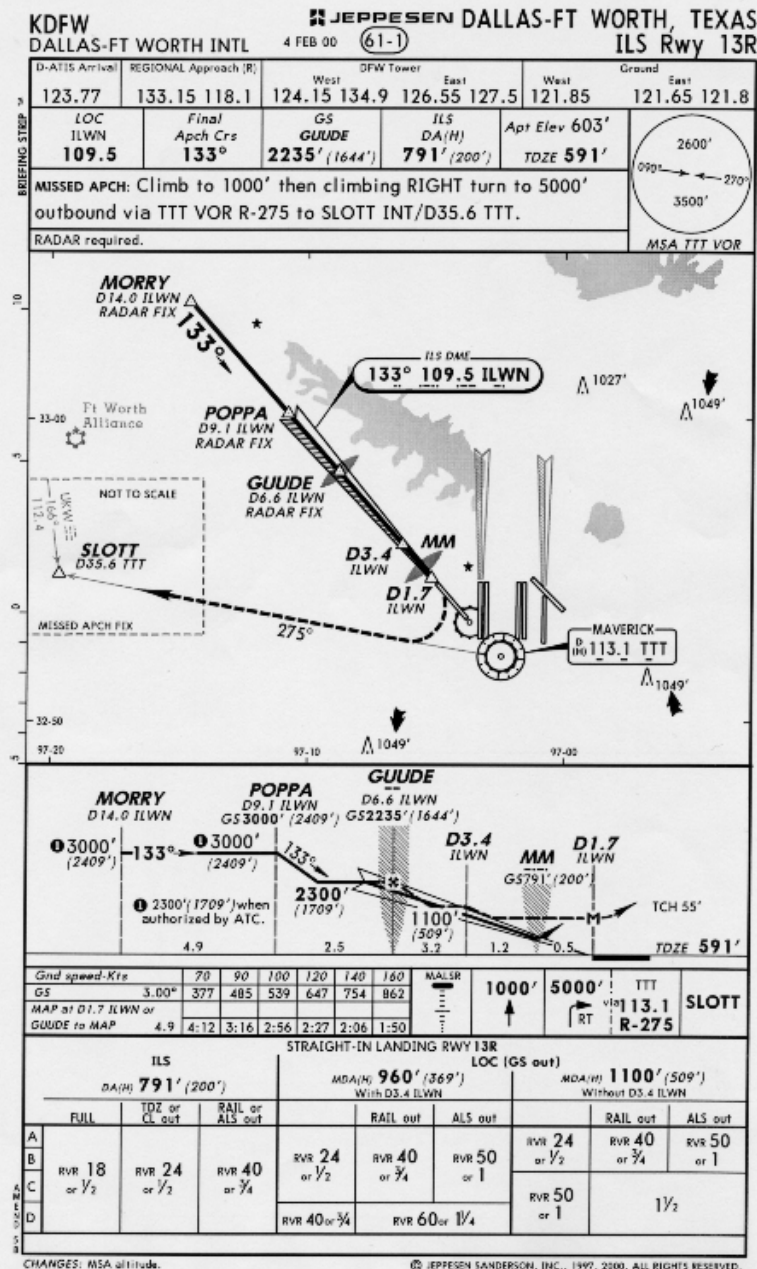
- A self-spacing clearance overrides the charted speeds.
- A s p e e d c spacing clearance.

ILS Rwy 13R Approach Chart

	distance	altitude	speed
BAMBE	41.8nm	11,000'	250
PREVO	27.5nm	7,000'	240
MORRY	13.0nm	3,000'	210
POPPA	7.9nm	3,000'	170
GUUDE	5.4nm	2,300'	150
13R	0.0nm	591'	135

The flying time from BAMBE to Rwy 13R is 600 seconds on the above speed profile.

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Notice: After 3/22/01 0901Z this chart should not be used without first checking JeppView or NOTAMs.



Only one entity (flight crew or ATC) is responsible for separation at any time.

- ATC has the sole authority to cancel self-separation
- Pilot can request the cancellation of free-flight

En Route Free Flight – Flight Crew Responsible

- Flight crew (upon acceptance) is responsible for separation assurance
- Flight crew can request ATC assistance for conflict resolution, flow control, and traffic management considerations

NOTE: If request is not received in a timely manor the flight crew is responsible for any loss of separation, but controller should assist the flight crew as soon as possible.

Transition Phase – Flight Deck Responsible (FL290 and above)

- ATC will provide “RTA” (Required Time of Arrival) advisory for meter fix
- Flight crew is responsible for separation and meeting RTA clearance time

Transition Phase – ATC Responsible (below FL290)

- Controller is responsible for separation and meeting meter fix arrival time
- Flight crew can request flight plan change
- Controller should consider user preferences

TRACON in trail spacing - ATC responsible for separation

- Flight crew can be cleared to maintain in-trail spacing, +/- buffer 70 sec +/- 10 sec)
- Controller can revoke clearance at any time (redundant)

En Route Phase – Free Flight With Approval

CE-6: Crew creates path, gets approval from ATC

- **Controllers are responsible for separation.**
- **Aircraft are on FMS routes to the *BAMBE* meter fix.**
- **Pilots monitor their traffic display and can use CDTI to create paths to avoid traffic.**
- **Pilot requests for path changes are down-linked to ATC.**
- **A high altitude controller uses CTAS to check for conflicts on proposed path and approve changes.**
- **TMA generates a sequence and schedule for all arriving aircraft at the north-west corner post.**
- **RTA and cruise speed advisories are automatically uplinked to arriving aircraft.**

En Route Free Flight

CE-5: Crew creates path and executes it.

- **Pilots are responsible for separation.**
- **High altitude controllers monitor traffic for safety and flow.**
- **Arriving aircraft are on Free Flight routes to the BAMBE meter fix.**
- **Pilots monitor their traffic displays and use CDTI to free maneuver to avoid traffic.**
- **Any changes in trajectory are down-linked to ATC and broadcast to equipped aircraft.**
- **A “super-sector” high altitude controller uses CTAS tools to monitor aircraft in the free flight airspace.**
- **TMA generates a sequence and schedule for all arriving aircraft at the north-west corner post.**
- **RTA and cruise speed advisories are automatically uplinked to arriving aircraft.**
- **Aircraft transition to positive ATC control before leaving FL290.**

Sector A

Sector B

UAL15
350 (B)*cleared route of flight at assigned altitude**sector boundary*

Controller “A” has handed-off UAL15 to controller “B”: Controller “A” remains responsible for separation of UAL 15, and must coordinate any flight path changes with Controller “B”

Controller “B” has accepted the hand-off from “A” and expects UAL15 to arrive via the assigned route and altitude. Additionally, any changes will be coordinated. Controller “B” will assume separation responsibility after UAL15 crosses the sector boundary.

Uncontrolled Airspace

In uncontrolled airspace pilots must maintain at least 500 feet from all obstacles (including other aircraft). They must also request permission to enter PCA. Permission is normally granted at a location, altitude and time.

Positive Controlled Airspace

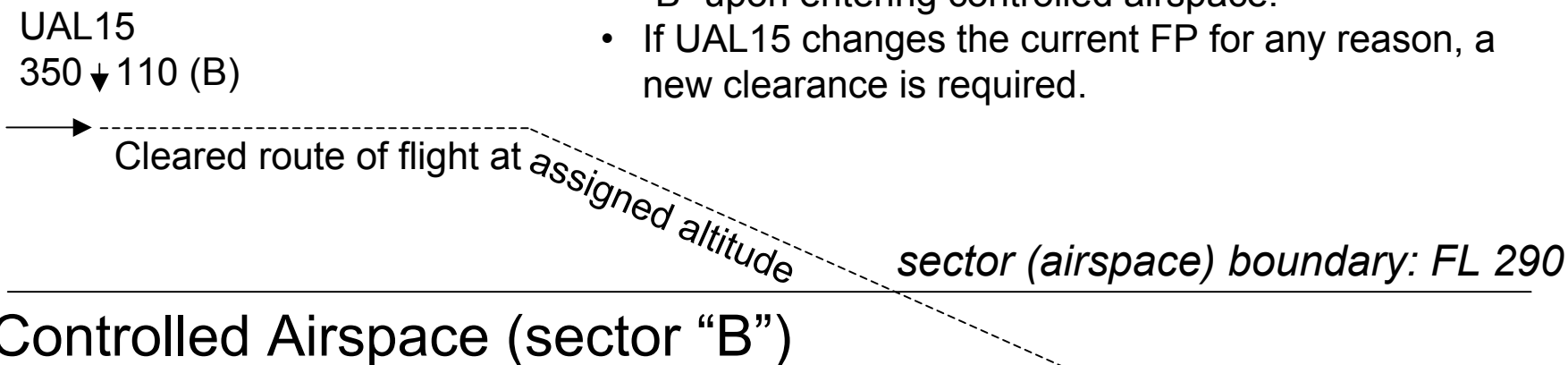
In PCA the controller is responsible for maintaining 3-5 miles separation between aircraft. All traffic wishing to enter must coordinate with ATC and receive approval. Before an aircraft enters or leaves PCA an agreed upon location, time, and altitude are established.

Uncontrolled Airspace



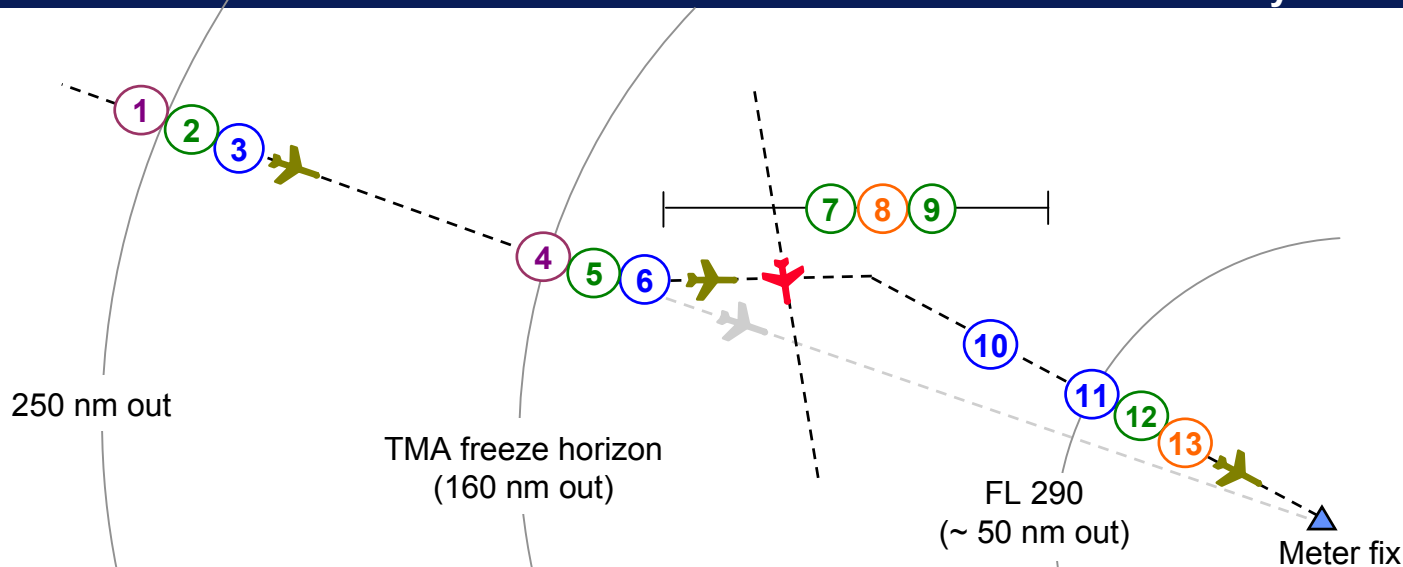
Free Flight Airspace

- UAL15 has received a clearance to enter controlled airspace via the Bowie F2 arrival along the current (broadcasted) FMC route and flight profile.
- **The current flight plan is conflict-free.**
- If no changes are required, UAL15 remains responsible for self-separation while in the free flight airspace. Responsibility transfers to Controller “B” upon entering controlled airspace.
- If UAL15 changes the current FP for any reason, a new clearance is required.

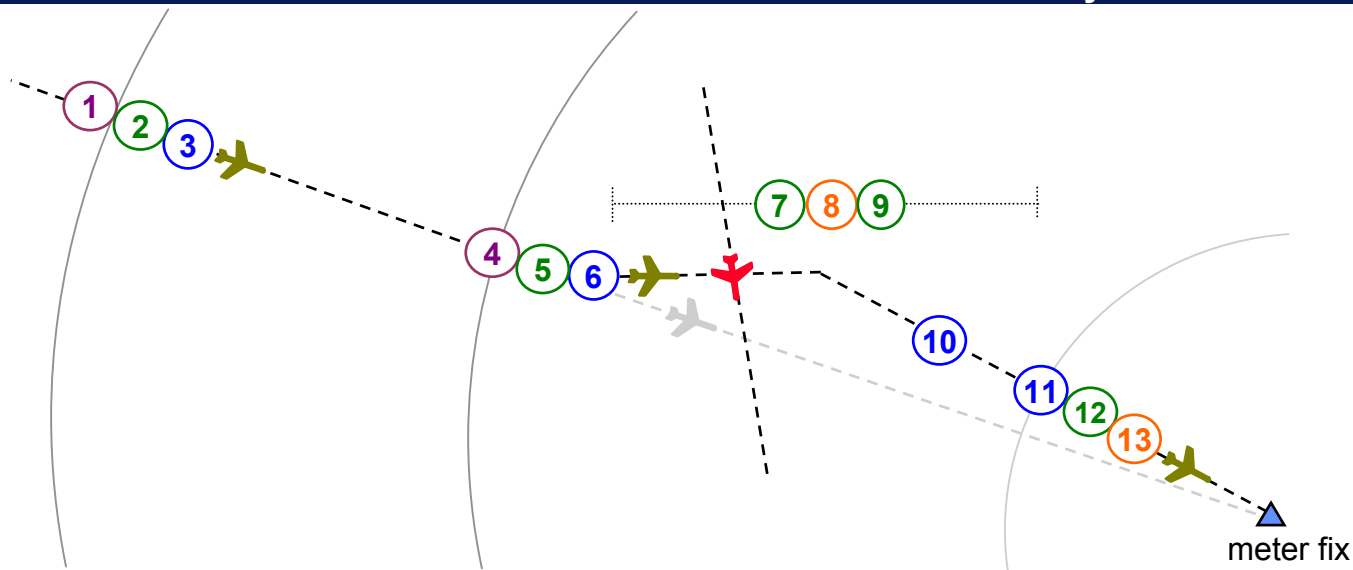


Controlled Airspace (sector “B”)

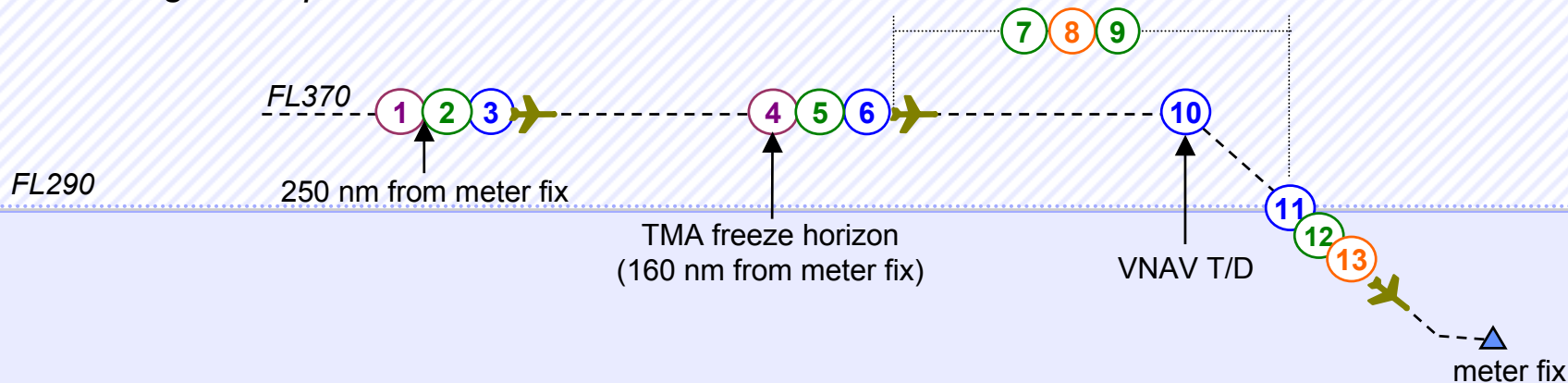
- Controller “B” clears UAL15 to enter controlled airspace via the Bowie F2 arrival (current flight plan).
- Any changes to the flight plan by UAL15 require coordination with Controller “B” and may cancel UAL15’s clearance to enter controlled airspace.
- Controller “B” assumes separation responsibility after UAL15 enters Sector B.



EVENT	FLIGHT CREW	FLIGHT DECK AUTOMATION	GROUND AUTOMATION	CONTROLLER
①			update STA, uplink RTA	
②	reviews RTA, adjusts flight plan	(receives RTA uplink)		
③		downlinks new flight plan		
④			(receives new flight plan) updates STA, uplinks final RTA to a/c	
⑤	reviews RTA, adjusts flight plan	(receives RTA uplink)		
⑥		downlinks new flight plan		
⑦	requests clearance to enter managed airspace		(receives new flight plan)	
⑧				approves request
⑨	enters meter fix altitude in MCP			
⑩		VNAV descent at FMS T/D alerts flight crew at FL290		
⑪				
⑫	reports entry to managed a/s			
⑬				acknowledges a/c





unmanaged airspace

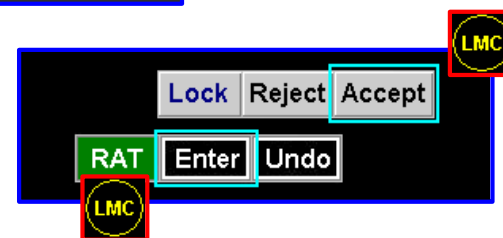


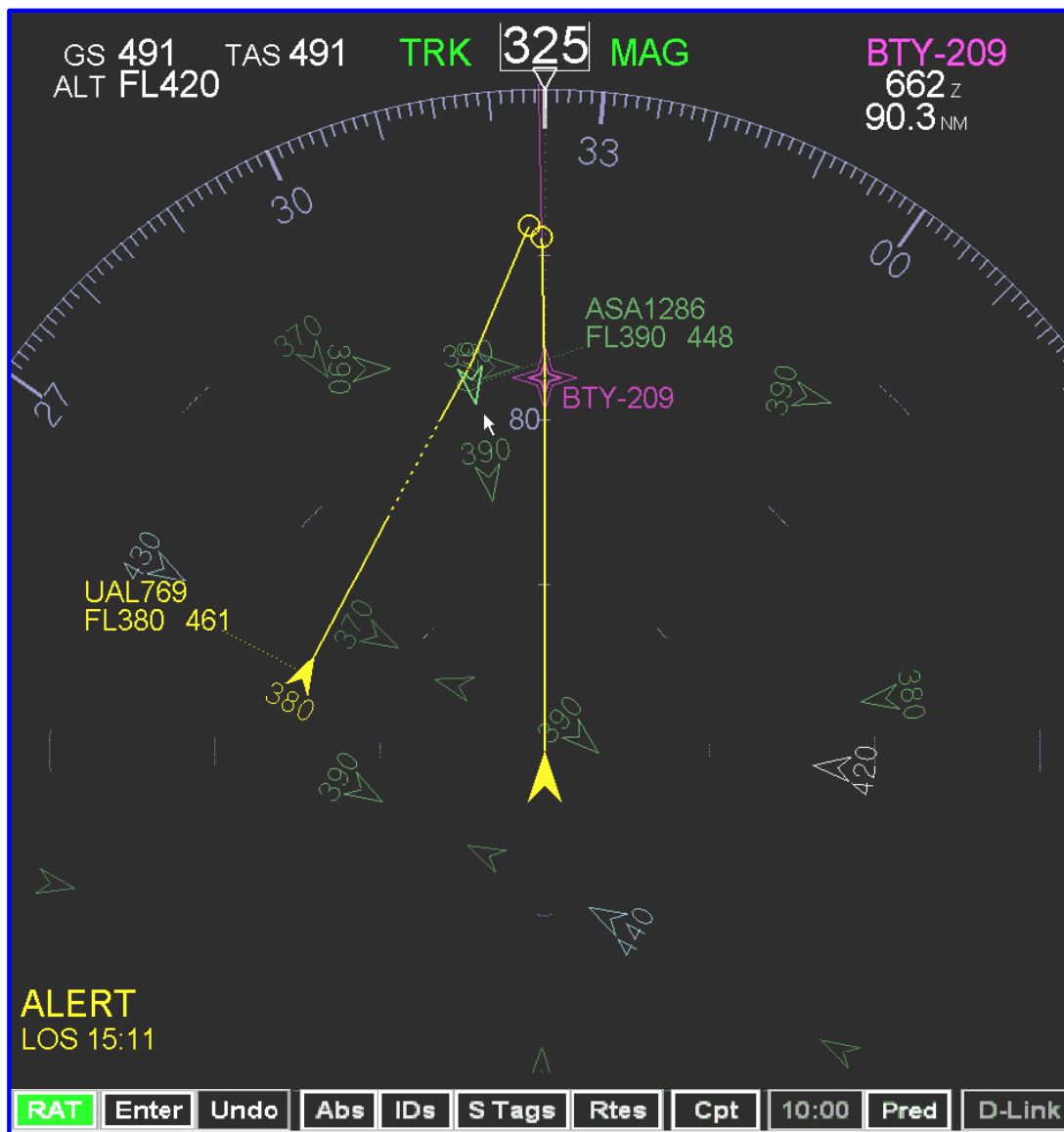
managed airspace

CDTI

Advanced – Route Assessment Tool (CE-5: Free Flight Airspace)

- » Loss of Separation Alert [**LOS 10:45**]
- » Engage Route Assessment Tool - RAT 
- » Modify ownship heading (speed, altitude) 
- » Enter >> Accept, to execute new flight plan
- » Data link flight plan modification





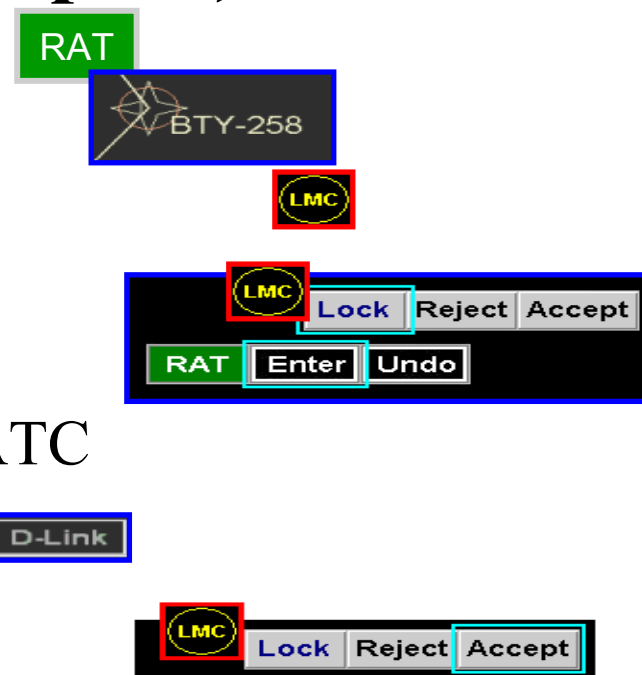


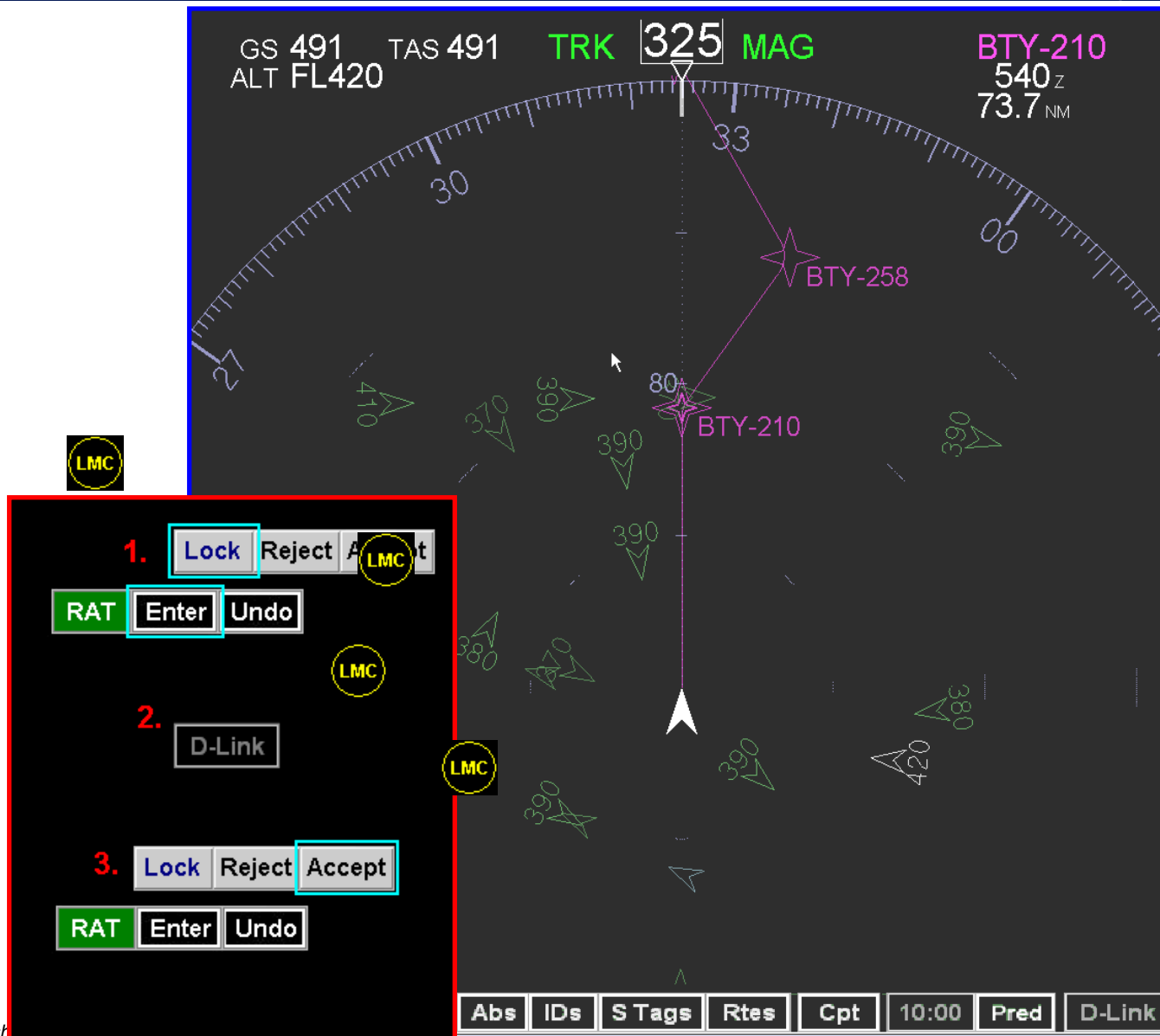


CDTI

Advanced – Route Assessment Tool (CE-6: Free Flight Airspace)

- » Loss of Separation Alert [**LOS 10:45**]
- » Engage Route Assessment Tool - RAT
- » Modify ownship heading (speed, altitude)
- » “Lock,” and submit flight plan change to ATC
- » Receive Data Link-ed ATC approval
- » Click Accept, to execute new flight plan





CE 11: Self-Spacing for Merging and In-trail Separation

- **Problem:**
 - **Conservative spacing buffers on final approach reduce arrival throughput and airport capacity**
- **Solution:**
 - **CDTI-equipped aircraft are cleared to maintain separation relative to a leading aircraft:**
 - **Flight deck displays and guidance for:**
 - **Self-spacing and merging**
 - **Fine tuning of fixed-time spacing**
 - **Controller displays & procedures for shared separation responsibility**

CE-11 Roles and Responsibilities TRACON Self-spacing clearance

- **TRACON self-spacing - ATC responsible for separation**
 - **Flight crew can be cleared to maintain in-trail spacing, +/- buffer**
 - **(for example ... 70 sec +/- 10 sec)**
 - **Controller can cancel clearance at any time (redundant)**

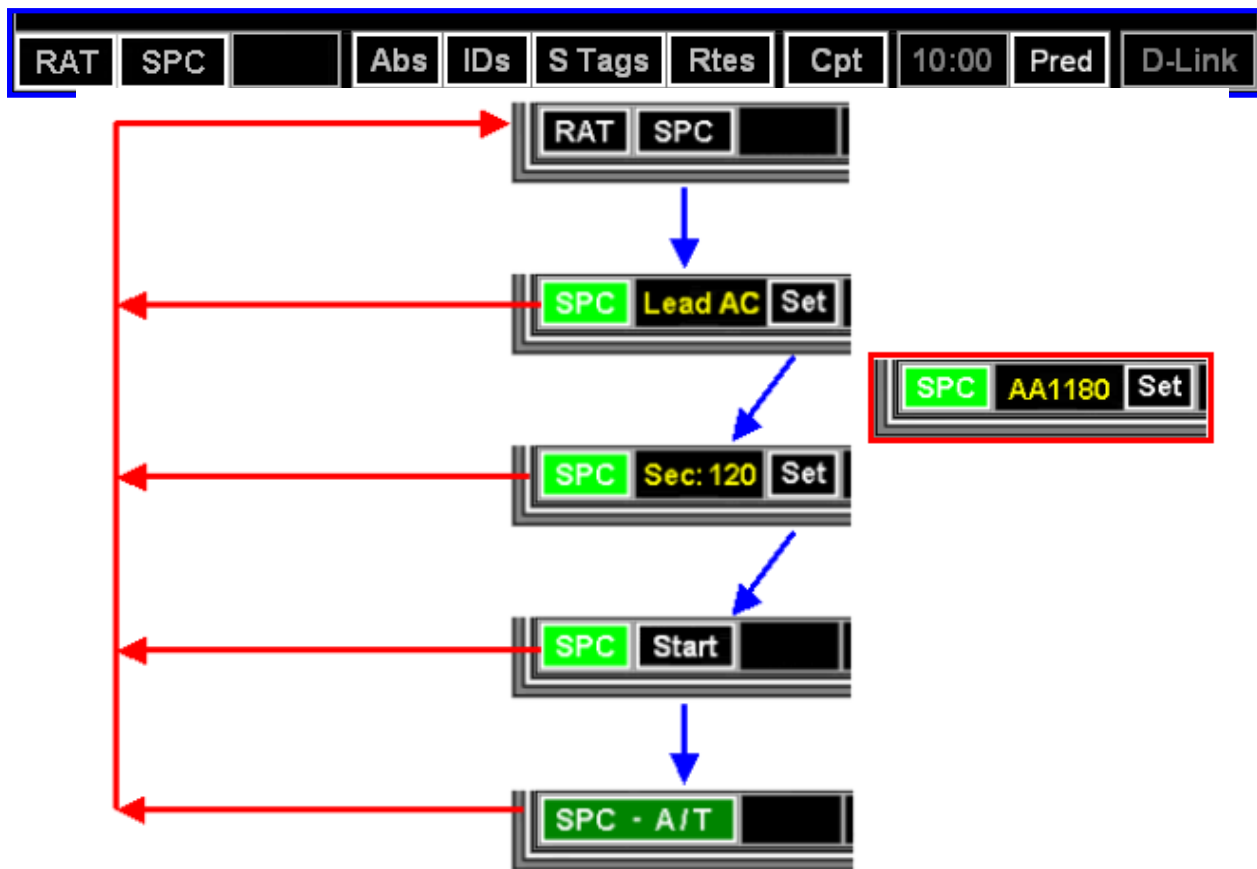
FMS approaches to runway 13R on the PREVO FMS Transition

- En route controllers deliver aircraft to the BAMBE meter fix on the TRACON boundary - (expected delivery accuracy is within 15 sec)
- TRACON controller clears aircraft to continue on the PREVO FMS Transition to RW13R.
- *“Descend via the PREVO FMS Transition, cleared ILS 13R approach.”*
- TRACON controller gives speed clearance to fine tune in-trail spacing - (expected delivery accuracy at PREVO is within 15s)
- *“Slow to 240 knots.”*
- If spacing is within tolerance, controller can clear by voice or datalink aircraft to self-space a specified number of seconds behind another aircraft.
- *“Follow AAL123, eighty seconds in-trail.”*
- Pilot is responsible for maintaining separation behind lead aircraft - (expected delivery accuracy at FAF is within 5 sec)



CDTI

Approach Spacing



CDTI

Approach Spacing



UAL1220
FL50 180
SPC: 90s



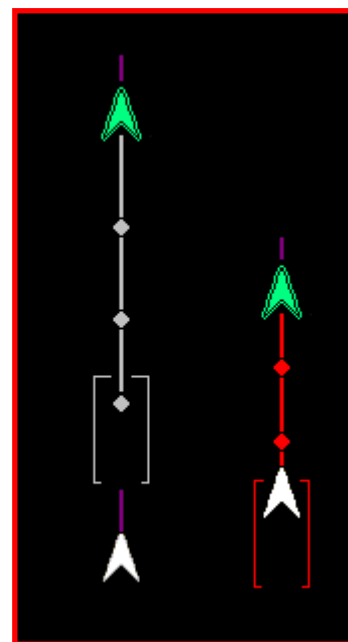
SPC - A/T

Abs

IDs

S Tags

Rtes



UAL1220
FL35 170
SPC: 90s

SPC - A/T

Abs

IDs

S Tags

Rtes

Research Plans

- **Develop and test decision support tools**
- **Three years of DAG-TM research**
 - **Develop and clarify concepts**
 - **Involve users (pilots, controllers, and dispatchers)**
 - **Conduct laboratory demonstrations of concepts**
- **Goal is to evaluate feasibility and potential benefits**
- **Deliver information and prototypes to the FAA by 2004**

END